STATE OF MICHIGAN

JOHN ENGLER, Governor

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Evaluation of Directional Drilling under the Great Lakes

October 1997

On August 12, 1997, Governor John Engler requested that the Michigan Environmental Science Board (MESB) conduct an evaluation of the state's regulatory procedures pertaining to directional drilling under the Great Lakes. Specifically, the MESB was requested to address the following directives:

1. Evaluate the risk of directional drilling causing contamination of the waters (through releases of hydrocarbons through the subsurface directly to the lake bottom) and shorelines of the Great Lakes,

2. Evaluate the potential impacts of directionally drilled wells on competing uses of the Great Lakes waters and shoreline areas, and

3. Review existing and potential permit conditions for adequacy in protecting the shoreline environment from adverse impacts.

A Panel, composed of four MESB and two guest scientist members, was assigned to address the Governor's request (see Attachment 1). One meeting of the Panel was held on September 23, 1997. Each Panel member was requested to review the information provided verbally and in written form from the Michigan Departments of Environmental Quality and Natural Resources (DEQ and DNR), industry, environmental organizations and citizens and then assigned a specific directive for response. Presented below are the Panel's findings and conclusions.

Directive 1. Evaluate the risk of directional drilling causing contamination of the waters (through releases of hydrocarbons through the subsurface directly to the lake bottom) and shorelines of the Great Lakes.

There have been more than 2,000 oil and gas wells directionally drilled in Michigan since the 1970's. Horizontal drilling is a special form of directional drilling that has been used for about 200 wells since 1985. Conventional, vertical wells have the bottom hole location directly below the surface location. A unique property of directionally drilled wells is that the bottom hole location (subsurface termination of the well) is at some distance laterally away from the surface location. Consequently, directional drilling has the advantage of siting the surface drilling and production equipment at a distance away from the surface immediately above the target reservoir zone where conflicts may

exist with environmental or land use issues. Directional drilling may also reduce the number of surface locations because several wells can be drilled to different bottom hole targets from the same surface pad. Figure 1 shows a directional and horizontal well path.

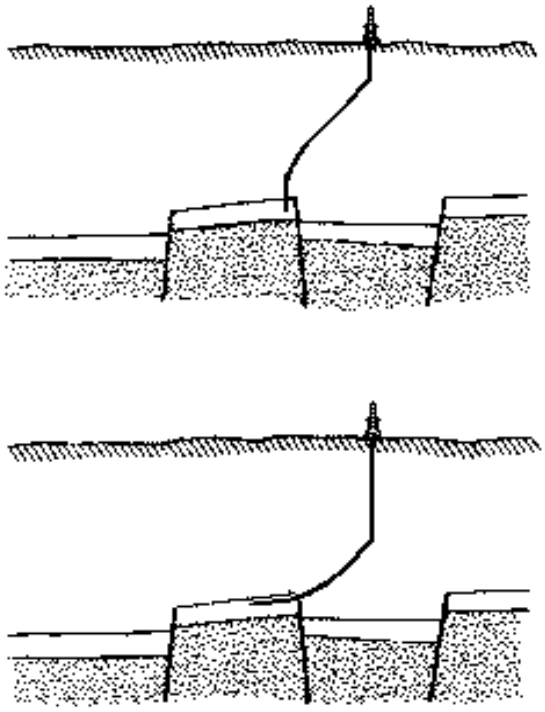

Figure 1. Directional (upper) and horizontal (lower) well paths.

The displacement of the bottom hole from the surface location may range from a few hundred feet to over ten thousand feet in the horizontal direction. Drilling and completing directional wells utilizes the same basic processes as a vertical well, except the drilling assembly is designed to track at an angle rather than to stay vertical. Casing requirements and borehole design are similar for both vertical and directional wells. Michigan's Oil and Gas Regulations (Parts 615 - 617, 1994 Public Act No. 451, as amended) and industry standards dictate the well design for all wells, including those directionally drilled.

Steel pipe casing is cemented into the borehole from the surface down to "... *a minimum of 100 feet below the base of the glacial drift into competent bedrock and 100 feet below all fresh water strata ...*" (P.A. 451, Part 615, R 324.408). Other zones in the well will also be cased to prevent hole collapse or unwanted fluid flow into or from subsurface formations. When oil or gas is produced from a reservoir formation at some depth in the subsurface, production tubing (another smaller diameter pipe) is placed in the hole to a depth at or near the bottom of the hole.

The installation of casing and production tubing creates integrity from the bottom of the hole to the surface. No fluids can escape into the surrounding formations with this

system in place. Figure 2 shows the well design for a horizontal well with several different diameter sections of casing throughout the well. When assessing the risk of fluid migration out of the borehole, the casing plan is one critical component for evaluation. An additional area of evaluation should focus on the geologic strata above the producing reservoir horizon. The existence of impermeable strata above the reservoir will provide additional protection from fluid migration toward the surface. In the case of drilling for Niagaran Reef reservoirs adjacent to Lake Michigan, there are thousands of feet of impermeable rock strata above the reef reservoir. Most Niagaran Reef reservoirs occur at greater than 4,000 feet depth in the area of Manistee County, Michigan. These reefs are overlain by more than 2,000 feet of impermeable strata comprised of shale, salt and anhydrite. In fact, the presence of some of these impermeable strata is the seal that has kept the oil and gas trapped in the reefs for over 300 million years. If any hydrocarbons could naturally leak through these layers, the reservoir would no longer contain any trapped oil or gas. Figure 3 shows a well with dual horizontal segments in a reservoir layer. Impermeable layers above and below encase the hydrocarbons. These fluids will move through the borehole only to the surface.

In directional wells, the surface location is at some lateral distance away from the bottom hole where the oil and gas are found. With proper well design and the geological subsurface layers that exist in Michigan, there is minimal to no risk of hydrocarbons reaching the surface to cause contamination in the area vertically above the bottom hole location of these directionally drilled wells. In Michigan, no subsurface fluids of any type have ever reached the surface through overlying formations directly above the bottom hole location of a directional well. The only path for fluids to the surface is through the well bore to the surface location.

Although the potential risk for contamination through releases of hydrocarbons is small at the well head, the risk is not zero and should be considered in siting the surface locations of these wells. It is possible to determine the area of potential risk around each well's surface location. The risk drops dramatically with the distance away from the well head. There is a finite distance away from the well head at which essentially no risk exists from that well. The currently existing directionally drilled wells with bottom hole locations under the Great Lakes have surface locations as close as 700 feet from the shoreline. Four of 12 are less than 1,000 feet from the shore, whereas the remaining eight are at distances greater than 1,000 feet from the shore.

The Panel concludes from review of available data, that there is little to no risk of contamination to the Great Lakes bottom or waters through releases directly above the bottom hole portion of directionally drilled wells into Niagaran Reef and deeper reservoirs. There is, however, a small risk of contamination at the well head. The of area away from the well head that is at risk can be estimated based on experience gained from existing contamination sites.

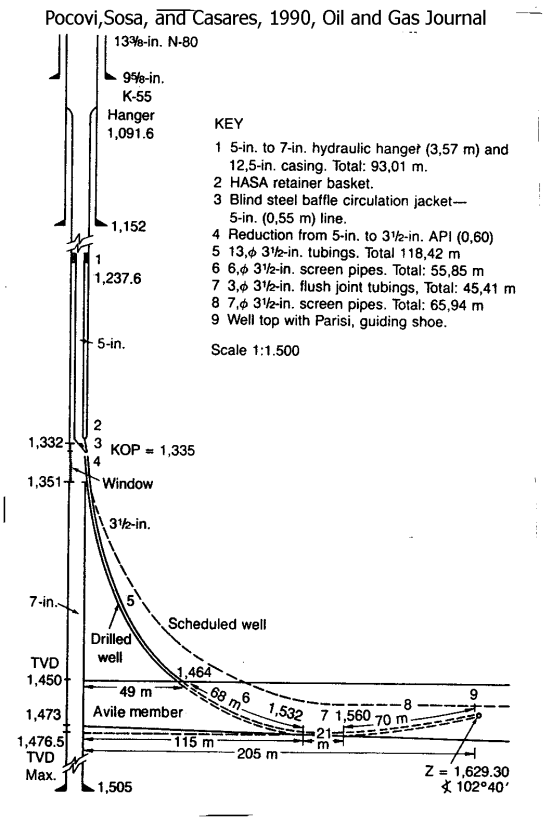

Figure 2. Design for a horizontal well with several diameter sections of casing throughout the well.

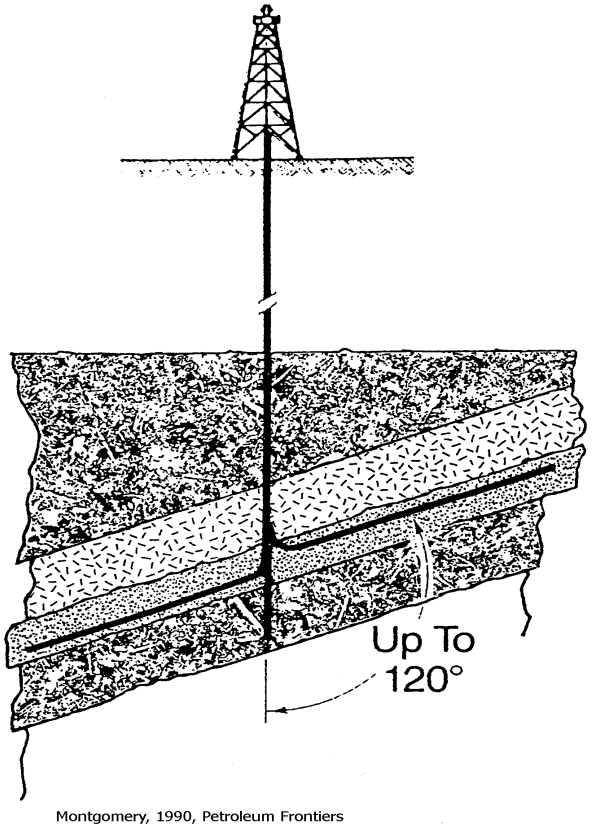

Figure 3. Well with dual horizontal segments in a reservoir layer.

Directive 2. Evaluate the potential impacts of directionally drilled wells on competing uses of the Great Lakes waters and shoreline areas.

Given its response to Directive 1 above, the Panel finds that there exists a greater risk for potential impacts to the shoreline environments where the well head and its associated infrastructure are located than to the aquatic environment of the Great Lakes. Based on a review of over 100 base maps from the Michigan Resource Information System (MRIS) and other sources, and on documents delineating oil and gas developments, natural features, critical dunes, endangered species, soils, and land use associated with the Lake Michigan and Lake Huron shorelines, the Panel identified two areas of potential environmental concerns (ecological and social/aesthetic) that could have an impact on and, consequently be in conflict with, directional drilling on the Great Lakes' shoreline.

Ecological impacts may be derived from the physical location of the well and its associated equipment and distribution pipelines in critical or unique biological areas such as wetlands, sand dunes, etc., and the occurrence of some unforeseen accident which would degrade the environment. Such issues, depending on the specific location of the well or wells, could involve anything from a localized loss of land, reduced carrying capacities, reduced primary and secondary productivity, decreased densities of some and increased densities of other species of animals and plants to irreparable loss

of a given resource (e.g., loss of some unique species of animal or habitat type, or contamination of a potable ground water aquifer). With any directional (or for that fact, vertical) drilling proposal, impacts to ecological resources will occur. However, the Panel concludes that the ecological impacts can be minimized by identifying and prohibiting oil and gas development in areas where the ecological resources are either highly sensitive to perturbation or unique, use of the most advanced but proven technology and the employment of rigorous permit requirements to help ensure the reasonable protection of all resources in developable areas.

From the Panel's perspective, the social/aesthetic impacts involve the greatest potential for impact inconsistencies and incompatibilities of activities on adjacent properties. These social/aesthetic conflicts may result from the differences in expectations of "quality-of-life" parameters like noise, odors, congestion, vistas and undisturbed landscapes (natural but not unique or critical habitats), recreation and tourism between coastal residential, recreational and industrial land uses. The Panel views the social/aesthetic issue to be one primarily of coastal development and zoning irrespective of vertical or horizontal drilling. While technology and science can certainly help to lessen the impacts and even resolve several of the conflicts that may appear, most of these types of issues will require comprehensive environmental planning, communication between all stakeholders and compromise in order to be resolved.

Directive 3. Review existing and potential permit conditions for adequacy in protecting the shoreline environment from adverse impacts.

Regulation of directional drilling activities in Michigan is based on provisions contained in Michigan's Oil and Gas Regulations (Parts 615 - 617, 1994 Public Act 451, as amended) and its Administrative Rules, Natural Resources Commission (NRC) Policy 2306 of April 13, 1995 (Oil and Gas Leasing Policy - State-Owned Minerals) and the DNR Oil and Gas Lease. The Authority to lease state-owned minerals vests with the DNR. Regulatory functions of the oil and gas program vests with the DEQ. The various regulatory and policy provisions contain a variety of requirements which deal with technical aspects of the actual drilling operation and requirements designed to address the environmental concerns. Overall, the Panel finds that while the Oil and Gas Regulations and Administrative Rules, NRC Policy and the DNR lease provisions when taken together provide considerable protection to the Great Lakes' aquatic and shoreline environments, most of the environmental conflicts could be more readily resolved and the Great Lakes' aquatic and shoreline environments better protected if the lease agreement required an aggressive environmental impact assessment and stakeholder participation prior to the lease sale. Additional recommendations to enhance the level of protection are presented below.

A. <u>Streamline Process.</u> One of the problems encountered by the Panel in reviewing the various regulations, policy statements and lease provisions was the fact that it was confusing trying to discern what an applicant has to do first, get a lease or get a drilling permit, or get both simultaneously. Although not strictly a science or technical recommendation, the Panel strongly suggests that the process could be streamlined and better coordinated between the DEQ, DNR and NRC to make it more clear, remove some of the duplicative steps and/or requirements contained in both the lease and the

permit processes and add, where needed, steps not currently included in either of the processes. This, in turn, should assist applicants in preparing and the regulators in reviewing the application, and the public in better understanding of the process.

Related to the above issue are the requirements of the DEQ regulations and rules through its environmental impact assessment process and the DNR lease agreement through its requirement of a development plan to request similar and, in some instances duplicative, environmental information and/or analyses. The Panel suggests that the leasing process deal with environmental land use impacts and conflict analysis and that the oil and gas permit process focus more on the technological impacts of directional drilling to the environment. Applicants that cannot obtain a lease due to an inadequate or unacceptable environmental analysis should not proceed to the oil and gas permit process.

B. Sealability. One of the issues unique to directional drilling compared to vertical drilling is the potential for vertical leakage point of oils and gas from the recovery point to the overlying lakes. Successful isolation of escaped oil and gas fluids from the overlying lakes depends on the ability of the overlying geologic units to act as a barrier or seal. During the Panel meeting, the high degree to which the geologic units would act as a seal for active and proposed directionally drilled sites were discussed and demonstrated. The Panel recommends that such discussions on the ability of the geologic units to act as a seal be required by the DEQ in permits for directional drilling. Sources of information for demonstrating the "sealability" of the geological units might include knowledge of rock units on shore and of subsurface geology from off shore seismic data.

C. Coastal Zone Development Inventories The ecosystem characteristics of the coastal zone vary considerably among the Great Lakes. Lake Michigan is characterized predominantly by sand dunes. Setbacks running parallel to the shoreline can define the barrier dune and buffers for such concerns as noise and odor. This restricts development to a setback of around 1,500 feet. Unique and sensitive land area exclusions are then imposed on the remaining locations. Lake Huron, on the other hand, is characterized by meandering riverine flood plains and coastal wetlands. These can extend miles inland from the shoreline. Setbacks alone will not address the issues of environmental protections.

The Panel recommends that comprehensive coastal zone environmental inventories be compiled for both Lake Michigan and Lake Huron in order to clearly identify and evaluate, at a minimum, areas that are already impacted with oil and gas development, areas where leases could not be issued for future development (e.g., due to non-resolvable environmental constraints) and areas where directional drilling development leases could be allowed provided that such development could be documented as to cause only minimal and mitigable environmental impacts and conflicts to the shoreline. The existing DNR MRIS system supplemented with local land use plans could be used as a basis to identify the above areas. Given the great complexity of the Lake Huron and Lake Michigan shorelines and the need to afford the greatest environmental protection, such coastal zone evaluations should be considered a prerequisite before leasing of any of the Great Lakes' bottomlands.

D. Mandatory Use of Existing Infrastructure. The greatest ecological and social impacts of oil and gas developments are the required networks of transportation infrastructure. Pipelines, roads and transmission corridors can fractionate the landscape and can open virgin or undisturbed areas to intense recreation activities. Directional drilling allows greater flexibility in locating drill sites. Consequently, borehole locations can be selected to maximize the probability of using existing infrastructures and minimizing intrusions into such landscapes. Lease provisions currently require that the lessor route all pipelines from the well site to follow existing well roads or utility corridors; however, it does not prohibit, for instance, the development of new roads to the wells. In order to afford the greatest environmental protection, the Panel recommends that lease sales should specifically prohibit the construction of any new infrastructures and limit oil and gas development to areas where existing infrastructures (pipelines, transmission lines and roads) are already available to minimize intrusions into virgin or undisturbed areas and to prevent further intrusions into minimally disturbed areas.

E. Residuals. The coastal zones of the Great Lakes are generally characterized by permeable soils and high water tables. Materials such as brines, drilling muds or bulk fuels should not be stored for long periods of time or be disposed of on-site. What is stored for short periods of time should be thoroughly protected from reaching the underlying or adjacent environments. The current oil and gas regulations attempt to deal with brines and bulk fuels by requiring temporary, above ground and monitorable storage. This is not the case for drilling muds which may be stored and eventually buried in plastic-lined pits. The Panel concludes that the need to store any residue in ground is nonexistent given current technology and recommends that no residues should be stored above ground for any extended period of time without a thorough chemical analysis of the material being stored and a state-of-the-art, operable and monitorable leak detection system.

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